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Utilization of Water Disposal Results Condensation of Condenser Geothermal Power Plant as a Micro-Hydro Powerplant

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Abstract— **The problem is almost all Geothermal Power Plant (PLTP) using a conventional system. In the conventional system with condensing steam turbines, steam turbines will be used to play to produce electricity. After experiencing an expansion in the turbine, the steam is condensed at a lower pressure. In a binary cycle system, the primary fluid which is the main heat source will heat the secondary fluid through heat exchanger equipment (heat exchanger). Steam from the secondary fluid is then going to move the turbine to generate electricity. Both the conventional system and the system of binary cycle power plants of both systems are, in fact throw the rest of the process (water disposal) by injecting into the earth, where it is very unfortunate because the waste water as the rest of the process still has the potential to generate electricity. In this study we will design a system of micro-hydro power plants with no way of excess waste water is injected into the earth, but is collected in a tub container (reservoir). Making the reservoir is intended to accommodate the existing water discharge when not fulfilled in driving turbines. Then made weir / intake and through a channel of water flowed into the pipe carriers rapidly (penstock) to drive the turbine by utilizing a high fall of water that leads into the desired electrical power. For evaluation, use the principles of thermodynamics law. The final result in assessing the utilization of excess wastewater condenser condensing the geothermal power plants are known from the calculation of the amount of condensate produced per-hour is 1065,026 kg. From the calculation of the design of micro hydro power plants, water potential energy obtained for 100,550 Watt, turbine power generated by 60,330 watts, the power generator can generate electric power for 38,611 Watt or 38.611 Kilo Watt.**

Keywords— **geothermal power plant, condensing result, condenser, micro-hydro power plant**

I. INTRODUCTION

Lahendong geothermal field is located in Lahendong, in Manado City area, including North Sulawesi Province. Generally, water located in the ground, even in the Heat up by magma, will not be turned into steam, because of the large earth pressure. By way of drilling, the hot water has a way out. Arriving at the surface of the earth, will be transformed into high pressure steam. These steam turbines are used to drive a geothermal power plant (PLTP). According Lombogia (1997), Development of geothermal power plant (PLTP) Kamojang in Garut West Java, with a capacity of 30 Mega Watt as Unit I geothermal power plant is a plant that uses conventional system using geothermal energy at temperature above 180 0C (berenthalpy geothermal high) and for this study we tend to utilize geothermal energy temperature below 180 0C, which generally geothermal energy in Indonesia into low or moderate (berenthalpy geothermal low and moderate). By looking at the geothermal potential spread throughout Indonesia, the selection of Lahendong geothermal field as a working area of exploration and production company PT Pertamina, made feasible the design of geothermal power plants with a potential Lahendong 2.5 Mega Watt.

The problem is almost all geothermal power plants using conventional systems. In the conventional system with condensing steam turbines, steam turbines will be used to play that produce electricity. After experiencing an expansion in the turbine, the steam is condensed at a lower pressure. In a binary cycle system, the primary fluid which is the main heat source will heat the secondary fluid through heat exchanger equipment (heat exchanger). Steam from the secondary fluid is then going to move the turbine to generate electricity. Both the conventional system and the system of binary cycle power plants of both systems are, in fact throw the rest of the process (water disposal) by injecting into the earth, where it is very unfortunate because the waste water as the rest of the process still has the potential to generate electricity.

According to Hidayat. (1981), in direct contact condenser, the steam from the turbine and cooling water from cooling tower intersect directly (mixed together). Therefore, the intersection occurs directly between the cooling water with residual steam turbine, the condensate produced is not as pure as the condensate produced by condenser surface. Due to this immediate intersection, then in direct contact condenser, natural steam that poured from the geothermal production wells that also contains a variety of gases, of which there are gases that can not be condensed (non-condensable gases) will contaminate the results of its condensate.

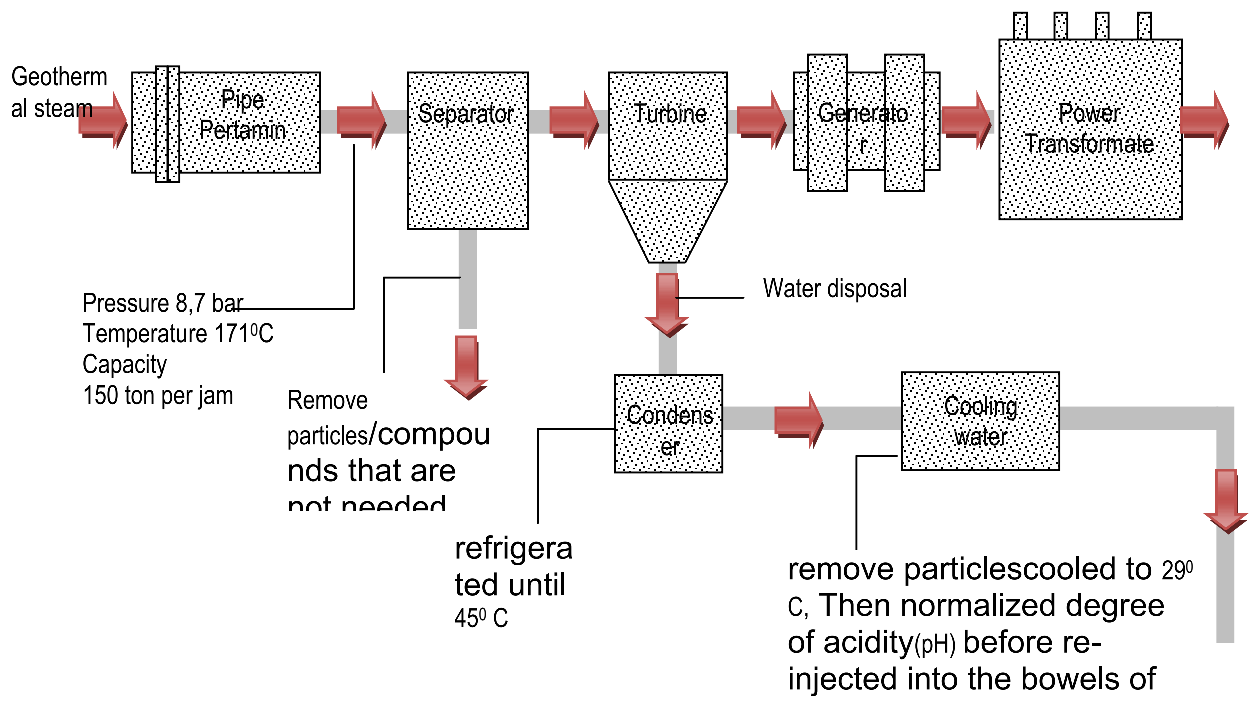
According Mayasari (2003), in designing a micro-hydro power (MHP) in the design of the generating capacity needed by an element that is specific speed turbine water. With known quantities of specific speed turbine, it can be re-designed capacity by determining quantities of the components of the system of micro hydro power plants (MPP) such as buildings intake (bug)-dam, the channel carrier, settling tanks and tranquilizers, channels pelimpas , fast pipes, house plants, and severage.

In this study we will design a system of micro-hydro power plant with the excess wastewater from a geothermal power plant is not injected into the earth, but is collected in a tub container (reservoir). Making the reservoir is intended to accommodate the existing water discharge when not fulfilled in driving turbines. Then made weir / intake and through a channel of water flowed into the pipe carriers rapidly (penstock) to drive the turbine by utilizing high-maturity so happens that the desired power micro hydro power plants (MPP) is basically utilizing the potential energy of water (water falls). The higher the water falls (head), the greater the potential energy of water that can be converted to electrical energy. Components of the system of micro hydro power plants (MPP) consists of building the intake (bug)-dam, the channel carrier, settling tanks and tranquilizers, pelimpas channels, pipes rapidly, house plants, and sewer. Objectives of this study to estimate the wastewater generated by the condenser geothermal power plant (PLTP), can generate electric power through the design of a system of micro-hydro power plants (MPP).

II. RESEARCH DESIGN AND MATERIALS

II .1 Materials Research

- Wastewater from the condenser of the condensation of geothermal power plants
- micro hydro power plants



2.1 Diagram of geothermal power plants with wet steam cycle

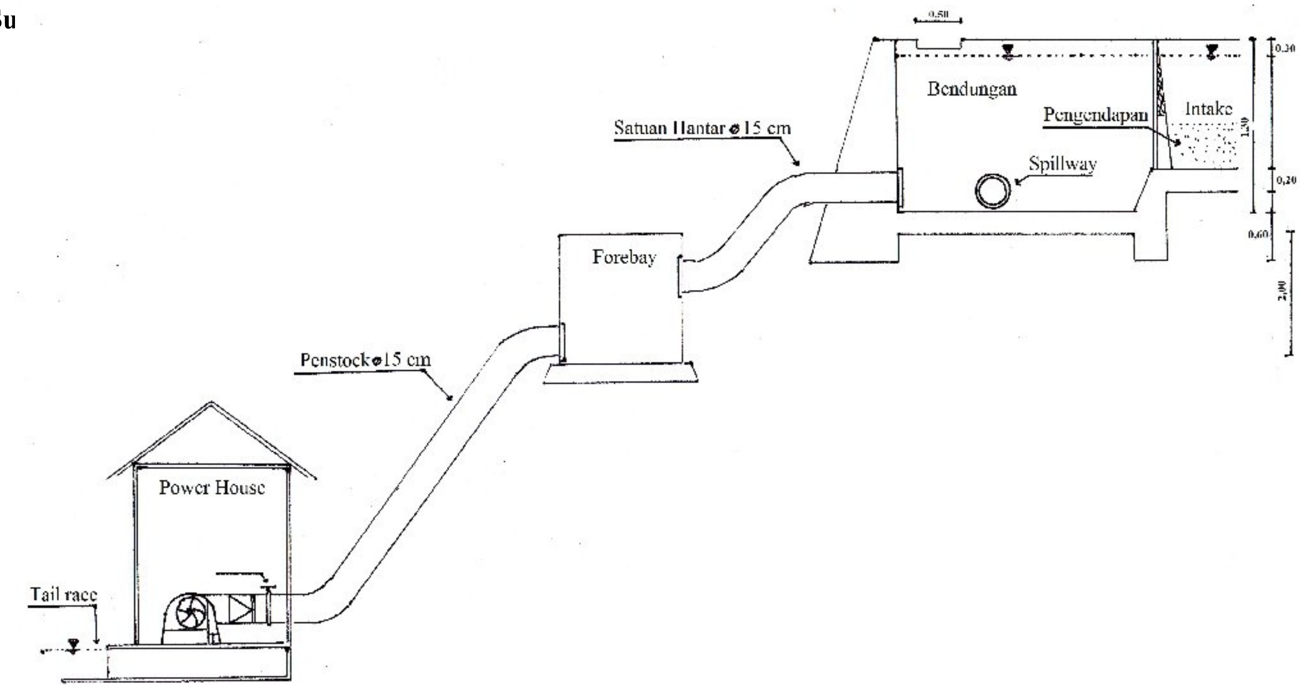


Figure 2.2 System circuit micro-hydro power (MHP)

2.2 Research Design

Some calculations were performed using the legal principles of thermodynamics (Moran and Shapiro, 1992), based on the theory with equations (1) through equation (6) and based on technical data from Geothermal Power Plant (PLTP) with a capacity of 2.5 Lahendong Mega Watt.

1. Calculation of Steam Turbine Work PLTP
   Calculated from the formula:. $W = \eta_T \,.\, W_S$.. *BTU/lb* (1)

2. Approximate Calculation of Steam Turbine Steam Flow Rate in PLTP Calculated from the formula:

$$m = \frac{W}{\eta_T (h_1 - h_{2S})} \quad (2)$$

3. Estimates on the Condenser Cooling Water Requirement Calculated from the formula:

$$W = \frac{W_S (h_{2f} + X.L - h_3}{(t_3 - t_2)} \quad (3)$$

4. Calculation of potential energy of water
   Calculated from the formula : $W = \overset{o}{m}.g.h$ (4)

5. Turbine Power Calculation
   Calculated from the formula: $W_T = \eta_T .W$ (5)

6. Calculation of the Power Generator
   Calculated from the formula: $P_G = \eta_{Trans} .\eta_G .W_T$ (6)

III. RESULTS AND DISCUSION

III.1 Calculation Results

To calculate the approximate steam turbine work Geothermal Power Plant (PLTP) Lahendong 2.5 Mega Watt capacity, according to Imam Hidayat (1981) can use the following formula:

W =□ T . WS ....BTU / lb

with:

W = actual working of the steam turbine, in BTU / lb.

WS = working isentropik from the turbine, the steady flow process with the assumption that: the kinetic energy (KE) = 0, potential energy (PE) = 0, and heat is transferred by the system (Q) = 0. in BTU / lb

η_T = isentropik efficiency, in %

Work isentropik of steam turbines, are:

WS = h1 - h2S, BTU / lb.

with:

WS = working isentropik from the steam turbine, in BT / lb.

h1 = throttle enthalphy, in BTU / lb.

h2S = enthalphy on the throttle and the exhaust pressure, entropy, in BTU / lb.

1. Basic Calculation of a Steam Turbine Work PLTP

Determined the selection pressure on the steam turbine, is as follows:

Inlet pressure = 10.4 Bar.absolut = 150.872 psia.

Outlet pressure = 1.42 Bar.absolut = 20.599 psia.

Based on the steam table readings, taken from the book " Fundamentals of Engineering thermodynamics “ by Michael J. Moran., Howard N. Shapiro., 1992 ", then: For the inlet pressure amounted to 150.872 psi, from the results of interpolation in the can: h_1 = 1194.99 ≈1195 BTU / lb S_1 = 1.5656 BTU / Lbm ^{0}R For the outlet pressure of 20.599 psia, the interpolation results, obtained: $S_{F\ 2S}$ (entropy of vaporization) = 0.3379 BTU / Lbm ^{0}R. $S_{fg\ 2S}$ (entropy of saturated vapor) = 1.3650 BTU / Lbm ^{0}R S_{2S} (constant entropy process) = where to isentropik process, cost the same as S_1, ie = 1.5656 BTU / Lbm ^{0}R. S_{2S} is equal to the sum of S_F and $S_{fg\ 2S}$ multiplied by X_{2S}, with X_{2S} called "moisture",

And so: $S_{2S} = S_{f\ 2S} + (S_{fg\cdot 2S} . X_{2S})$; Next: = 0.3379 + 1.5656 (1.3650. X_{2S})

$$X_{2S} = \frac{1.5656 - 0.3379}{1.3650} = 0,899 \approx 0.90$$

, Then X_{2S} = 0.90 x 100% = 90%. h_{2S} (enthalphy on entropy and exhaust throttle pressure), equal to the sum of one rated enthalphy liquid with the results of multiplication between enthalphy with moisture evaporation. So: $h_{2S} = h_{f\ 2S} + (h_{fg.2S} . X_{2S})$ From reading the steam table as above, to the inlet pressure in may magnitudes $h_{f\ 2S}$ and $h_{fg\ 2S}$, namely: $h_{f\ .2S}$ = 197.73 BTU / lb. $h_{fg\ 2S}$ = 953.15 BTU / lb X_{2S} = 0.90 the h_{2S} = 197.73 + (953.15. 0.90) = 1055.57 BTU / lb. So work isentropik of steam turbines, are: $W_S = h_1 - h_{2S}$ = 1195 - 1055.57 = 139.43 BTU / lb. With a turbine efficiency of 80%, I have got "real work" of the turbine is equivalent to: time : $W_{KT} = \eta_T . W_S$ = 0.80. 139.43 BTU / lb = 111.544 BTU / lb. This means that for every one pound of geothermal steam, generate employment for 11.544 BTU.

2. Approximate Calculation of Steam Turbine Steam Flow Rate in PLTP

Mass flow of steam (steam flow rate) on the steam turbine, can be calculated from equation, and the steam turbine power output of 2500 kW and a turbine efficiency of 80%. obtained:

$$m = \frac{W}{\eta_T (h_1 - h_{2S})} = \frac{2,500}{0,80(1195 - 1055.57)} = \frac{2,500}{111.544} = 22.412 lb/hr$$

So the steam flow rate on the steam turbine for geothermal power is 22.412 lb / hr or 10.152 kg / hr.

3. Estimates of Condenser Cooling Water Requirement

Calculated from the formula, namely :

$$W = \frac{W_S (h_{2f} + X.L - h_3)}{(t_3 - t_2)}$$

Basic Calculation: Suppose that the steam that flows into the condenser equals the amount of steam that flows into the turbine. So there are not considered losses. Temperature condensate and chilled water temperature set at 38 ^{0}C and 28 ^{0}C. While the wetness of steam at the time of leaving the turbine is 12 % (based on estimated data from the plant). Thus: W_S = 10.152 kg / hr (from the calculation). h_{2f} = 159.21 kJ / kg (from steam table readings). X = 88 %, in the can of: 100 % - 12 % (wet steam leaving the turbine at the time). L = 117.43 kJ / kg (from steam table readings) h_3 = 159.21 kJ / kg≈h2f (because of direct overlap with water vapor cooling). t_3 = 38 ^{0}C and t_2 = 28 ^{0}C. From the prices and the equation above, in the can:

$$W = \frac{10.152(159.21 + 0.88.117.43 - 159.21)}{(38-28)} = \frac{1,049.087}{10} = 104.908 kJ/hr$$

So the required cooling water to condense steam geothermal counted 10.152 kg / hour, amounting to 104.908 kJ / hr. Cooling water is mixed with steam and a condensate with a temperature of 38 ^{0}C. So the amount of condensate produced per hour it is 10.152 x 104.908 = 1065.026 kg. By ignoring the existing losses, power produced by water as a high potential energy with plans for 10-meter fall, and is calculated from the formula: then: W = (1065.026 kg / hr). (9.8 m/s^2). (10m) m = 100,550 Watt. Furthermore, in calculating the power turbine, assuming losses from reservoir to be ignored and the efficiency of the turbine nozzle set at 60 %, then the existing turbine power for W_T = 60 %. W = 60 %. (100,550) = 60,330 Watt Watt. Turbine output power will be used as a tool to drive turbine generators will be connected to a transmission coupling with the transmission efficiency of 80 %, and a generator efficiency of 80 %, then the generator output power generated at : or

P_G = (0.8). (0.8) .60,330 = 38,611 Watts or 38.611 kilo Watt

3.2Discussion

In reviewing the results of the utilization of excess wastewater condenser condensing geothermal power plants are known from the calculation of the amount of condensate produced per-hour is 1065.026 kg. From the calculation of the design of micro hydro power plants, water potential energy obtained for 100,550 Watt, turbine power generated by 60,330 watts, the generator power generator power is obtained for 38,611 Watt or 38.611 kilo Watt. Seen that an important role acquire generating capacity of electric power are determined from a given fall height. But the high determination of the water fall is not haphazard, but based on the geographical conditions of local locations. Because of geographical conditions Lahendong geothermal field that is not possible to add high-falling water, then the determination of 10 meters is the number most ideal for the design of micro-hydro power plants (MPP).

IV. CONCLUSION

From the results and discussion, it can be stated that the utilization of excess wastewater condenser condensing the geothermal power plants are known from the calculation of the amount of condensate produced per-hour is 1065.026 kg.

From the calculation of the design of micro hydro power plants, water potential energy obtained for 100,550 Watt, turbine power generated by 60,330 watts, the generator power generator power is obtained for 38,611 Watt or 38.611 kilo Watt.

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